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**An empirical examination of the product variety management in brazilian bus body manufacturer**

**Um estudo empírico do gerenciamento da variedade de produtos em um fabricante brasileiro de carrocerias de ônibus**

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**Abstract**

The main purpose of this paper is to understand how product variety is managed in practice. In this sense, it presents a panorama of the various aspects of product variety taken from the academic literature. Despite the importance of the theme, there are few studies related to PVM (Product variety management) and this paper is useful for academics interested in it. This paper is one of the first efforts to fulfill the gap in the literature regarding empirical studies related to PVM. The study is classified as explanatory and descriptive and offers a complete overview of how PVM is applied in the automotive industry. It shows that product variety management is an interdisciplinary issue, as the literature suggests, and that its effects can be perceived in all corporate areas in different ways.

**Keywords:** Product variety; Product variety management (PVM); Bus body manufacturer; Automotive industry.

**Resumo**

O principal objetivo deste artigo é entender como a variedade de produtos é gerenciada na prática. Nesse sentido, apresenta um panorama dos diversos aspectos da variedade de produtos retirados da literatura acadêmica. Apesar da importância do tema, existem poucos estudos relacionados ao GVP (Gestão de variedades de produtos) e este trabalho é útil para acadêmicos interessados no tema. Este trabalho é um dos primeiros esforços para preencher a lacuna na literatura sobre estudos empíricos relacionados ao GVP. O estudo é classificado como explicativo e descritivo e oferece uma visão geral completa de como o GVP é aplicado na indústria automotiva. Isso mostra que a gestão de variedades de produtos é uma questão interdisciplinar, como a literatura sugere, e que seus efeitos podem ser percebidos em todas as áreas corporativas de diferentes maneiras.

**Palavras-chave:** Variedade de produtos; Gestão de variedades de produtos (GVP); Fabricante de carrocerias de ônibus; Indústria automotiva.

## 1. Introduction

Today, the increasing variety of products offered to customers has emerged as a major trend (Wang et al., 2008; Stäblein et al., 2011), and great academic interest has developed in the effects and consequences of product variety on production systems. Balakrishnan e Chakravarty (2008), Vaagen e Wallace (2008), Murthy et al. (2009), and Zhang e Huang (2010) reported that product variety refers to variations in product attributes and/or characteristics that allow for different product configurations. Escobar-Saldívar et al. (2008) characterized product variety as the number of existing product lines and the number of products offered in each line.

Elmaraghy et al. (2009) highlighted the difficulty of balancing the customer and company viewpoints on variety, offering sufficient variety to the customer while also considering the effect of that variety on production systems. Product variety is an effective strategy to increase market share because it enables a firm to serve heterogeneous market segments and to satisfy consumer's variety seeking behavior (Tang & Yam, 1996). These can involve differences in product features, packaging, or channels of distribution. These marketing strategies should result in sales growth or higher prices, and presumed profit, gained by meeting more specialized demands (Berry & Cooper, 1999). However, it is also generally accepted that a proliferation of products results in deterioration in manufacturing / logistics performance (Kim et al., 2005), what can result in higher forecast errors, excessive inventory for some products, shortages for others and higher costs (Thonemann, 2002).

This problem is especially challenging for firms because of the dearth of models and tools that they can use to achieve an appropriate balance between the positive and negative aspects of product variety. According to Elmaraghy et al. (2009), this lack of models and tools constitutes a significant gap in the literature. Elmaraghy et al. (2009) noted that managing variety at all levels of production and support is one of the most important priorities for companies in the current dynamic environment. The management of product variety makes it possible to offer customers a variety of products while simultaneously maintaining high levels of quality, responsiveness, and adaptation to change, thereby generating profits.

Within this context, the main goal of this article is to understand how product variety is managed in practice. In this sense, one empirical study embracing automotive sector in Brazil is conducted based on a conceptual framework for product variety management (PVM) developed by Reis et al (2013). This paper is one of the first efforts to fulfill the gap in the literature regarding empirical studies related to PVM and is useful for academics interested in the theme. Additionally, this article offers a complete overview how PVM is applied in the industry, which is carefully tailored for practitioners.

This paper is organized into five sections, being this one the introduction one. Section 2 reviews the product variety management concept from a literature perspective. Section 3 describes the research method applied, after that section 4 focus on empirical studies and discussion. Finally, section 5 offers the research conclusions and suggestions for future research.

## 2. Literature review

This section presents a panorama of the various aspects of product variety taken from the academic literature on the subject, including: definitions, trade-offs, product proliferation, variety and attributes.

## 2.1 *An overview of product variety*

First of all, it is important to establish some key definitions to ensure there is no ambiguity in further discussion. Product variety can be defined as the number of different versions of a product offered by a firm at a single point in time (Randall & Ulrich, 2001; Reis et al., 2013) and as the number of different product offered to customers (Pine, 1993).

An increasingly demanding market has placed pressure on companies to offer a wider variety of products (Scavarda et al., 2009). This fact has forced companies from different industrial sectors to respond, generally by augmenting the variety of their products through a combination of attributes (Mapes et al., 1997).

Over the past few decades, product variety has proliferated in a number of industries (Aoki et al., 2013). To analyze product variety it is necessary to understand which attributes compose this variety. In other words, what is a component of variety in one industry may not necessarily be a relevant component in another one. To give an example, for the electronics industry voltage characteristics are critical and are a component of the attributes that comprise total variety in this industry. On the other hand, for the bicycle industry, an attribute like voltage is not important, while attributes such as color and bicycle frame materials (aluminum, steel, alloy, carbon fiber) are.

The objective of the introduction of a new-product variation is to increase sales and maximize company profit (Er & McCarthy, 2006). And its effect can increase the complexity of demand forecast activities of the purchasing sector (Kotteaku et al., 1995) and production programming (Van Donk & Van Dam, 1996). Additionally Reis et al. (2013) concludes that adopting this strategy is important for maintaining the competitiveness of an enterprise.

## 2.2 *Product variety under different perspectives*

Product variety can be studied from the perspective of different areas which, in general, include: marketing; organizational behavior; engineering; (Novak & Eppinger, 2001; Goldenberg et al., 2001) and social perspective (Tang & Yam, 1996). However, the literature can be divided into two main streams areas: marketing (Bohlmann et al., 2002; Brynjolfsson et al., 2003; Hui, 2004 & Shankar, 2006) and operations management (Bennet & Forrester, 1994; Berry & Cooper, 1999; Thyssen et al., 2006; Vaagen & Wallace, 2008; Scavarda et al., 2009; Ståblein et al., 2011; Fischer et al., 2016).

In the marketing literature, high product variety has been found to enable a firm to satisfy the desires and needs of heterogeneous consumers (Tang & Yam, 1996; Berry & Cooper, 1999; Vaagen & Wallace, 2008; Fettermann & Freitas, 2017), to increase the probability (Kekre & Srinivasan, 1990), to increase market share (Pine, 1993; Quelch & Kenny, 1994), to increase sales (Chen & Iyer, 2002); to protect from new competitors and to maintain or increase competitive (Thyssen et al., 2006; Lafou et al., 2016; Unver et al., 2018). On the other hand, marketing research has also suggested that “excess” product variety may lead to selection confusion for customers, thus reducing the marginal benefits from variety (Wang et al., 2008).

On the other hand, in operations management literature, researchers argue that increasing variety raises general costs (Thonemann, 2002; Lafou et al., 2016) inventory cost (Fisher & Ittner, 1999), reduces operational performance (Macduffie et al., 1996; Silveira, 1998), increases R&D cost (Macduffie et al., 1996) and ultimately undermines sales (Ton; Raman, 2010). Higher product variety makes it harder to forecast demand precisely (Hsu & Wang, 2004) and maintain continuous supply (Thonemann, 2002), resulting in mismatches between product supply and demand, thus leading to product stock outs (Bennett & Forrester,

1994).

In industries where product substitutes are imperfect, such as the automobile and weapons industries, customers might backorder in the case of stock outs (Thyssen et al., 2006). However, in other industries, such as soft drinks and breakfast cereals, products can be easily substituted (Wang et al., 2008). Although sales may not be lost if substitution occurs within a supplier's product offering, lost sales will transpire when product substitution takes place across suppliers (Wagner & Friedl, 2007). Thus, stock outs that result from a high product variety strategy may ultimately hurt sales performance (Wang et al., 2008).

### 3. Methodology and research design

This section presents the methodology and research design applied to conduct the case study.

This study is classified as an “explanatory” and “descriptive” study. According to Yin (1994) exploratory and descriptive complement an explanatory study. This strategy is preferred when the researcher has little influence over events and when it is a contemporary phenomenon within some real-life context (Yin, 2001). Voss et al. (2002) argue that exploration is needed to develop research ideas and question. This article can be classified as an explanatory study because is the first effort to understand PVM best practices in the business arena.

The research was conducted through a deep case study approach. Case study is indicated for the investigation of contemporary phenomena within their real life context, particularly when the boundaries between them are not clearly defined. Thereby is recommended for current themes and situations where the researcher observes the facts and attempts to understand, systematize and analyze them (Yin, 2009; Voss et al., 2002).

The automotive sector was selected due to its economic importance (e.g. the automotive industry represented more than 22% of industrial GDP in Brazil and its total revenue is estimated at US\$ 46.9 billion in 2006 (Anfavea, 2016)), its operation in a high product variety volume environment its complex and expensive products (Aoki et al., 2013) and due to the fact it has been at the forefront of many managerial and industrial developments throughout the world (Pires, 1998; Thun & Hoenig, 2011).

The company to be studied is the biggest Brazilian bus body manufacturer with three industrial plants in Brazil and eight foreign ones (China, Egypt, South África, Argentina, Colômbia, India, and Australia). In Brazil it has two brands and an independent business unit. It is a market leader and is a major shareholder in other body manufacturers as well as holding a stake in some Brazilian suppliers such as seat makers and upholsterers. This article focuses on its main Brazilian manufacturing plant, which supplies parts and components to all its factories in Brazil and worldwide.

This research used a multitude of data sources as any finding or conclusion in a case study is likely to be much more convincing and accurate if it is based on different sources of information, following a corroboratory mode (Yin, 2009). The triangulation approach was adopted by combining different evidence's sources, while shifting between analysis and interpretation (Yin, 2009). Data were gathered utilizing interviews guided by a semi structured questionnaire, with different stakeholders involved in the decision process regarding product variety (each one lasting between two and four hours), in loco visits for direct observation and internal documents from both companies.

The interviews include the main professionals involved in the decision process regarding product variety for each company. The interviews were guided by a questionnaire incorporated the different aspects of

PVM based on the research framework developed by Reis et al (2013), organized into four dimensions: inputs, structure and processing, measures and outcomes.

The interview protocol included issues related to the four dimensions, more specifically regarding the main advantages and disadvantages of the variety, the main pressures influencing variety creation, the reasons to increase or reduce this variety, the consequences, the related costs, the managing procedures used, the adopted mitigation processes, existing measures and main outcomes seek. In the bus-body manufacturing seven employees who work in areas directly impacted by product variety were interviewed. They include a manager from each of the following areas: quality, marketing, commercial, logistics, human resources, and environment.

Given the key role that the interviewees played in the decision process regarding product variety decisions and their impacts, the relatively low number of interviewees does not pose a major constraint on the validity of the findings, in particular since the findings were triangulate from the interviews with the results from the plant visits. The research further drew upon contextual obtained in internal reports and documents of each company.

The case study used the framework for PVM developed by Reis et al. (2013), because is the framework tailored for PVM and it configures in the state of art. This framework is divided into 3 groups: inputs, structure and processing and output

Inputs in this case are pressures that influence the increase or decrease in the variety of products offered to customers. This dimension was organized into four groups: organizational pressure (firm); network-related pressure (supply chain); industry pressure (e.g. automotive industry or cosmetic industry) and environmental pressure (e.g. governmental policies, macroeconomic effects, social and environmental demands). These four main pressures could influence each other and impact the product variety offered in the market.

Structure and processing characteristics are the means that organizations use to deal with these pressures. These resources can be grouped into the following categories: (i) relationships and participants, which can be considered from both the intra-organizational perspective (when the focus is departments or areas internal to departments) and the inter-organizational viewpoint (when the focus is the various members of a supply chain); (ii) business processes; (iii) information technology; (iv) mitigation strategies; and (v) measures.

Finally, outcomes are the objectives that companies hope to achieve as a result of efficient PVM.

#### **4. Empirical findings and analysis**

This section presents the finding and analysis based on PVM framework.

##### **4.1 Inputs**

At the bus-body manufacturer the support for and the responsiveness to, the diverse demands for client customization were the most-mentioned pressures that a company needs to deal with.

The first pressure highlighted is in product characteristics. The marketing manager pointed out: “Our product line needs to adapt itself to the needs of each client: the conditions of use and the utility the client gives to the product. An example is a company that exclusively runs highway coach lines. You would think that this company would purchase just one product: highway coaches. However, its national and international highway coach lines possess distinct characteristics among themselves. It is one thing to set up a bus line that



connects the South and the Southeast of Brazil and quite another to set up one that connects Brazil to another South American country. The vehicles' needs are going to be different, and we have to understand this in order to be able to offer the right product to our client. Just to give an example, on some international coach routes two drivers travel on the vehicle, so a special seat has to be installed for the resting driver." A commercial manager corroborated the marketing manager's comments and added, "In the sales process the first step is to understand the characteristics of the client's business operation; this is fundamental in defining the sales operation. If we don't understand the operation, we will not be able to offer the proper product and adaptations that suit our client. The thing is that we put the product together with the client guided by his needs and the technical restrictions of the product. This service has differentiated us in the market- from pre-sales to post-sales service- and is reflected in our high levels of client fidelity. We have customers who have been with us for over 50 years! "Starting with the comments of the commercial manager, two pressures can be identified: differentiation from competitors and customer choice process.

Pressure related to the reduction of product lifecycle has been highlighted as being one of the factors that has had the most impact on all areas. The commercial manager commented that reductions in lifecycle have increased the need for sales force training as well as more frequent up-grading of sales and marketing materials such as product catalogues. It was pointed out by the marketing area that the internal administration of information by the company is an important challenge and that once a product line has been changed the majority of processes need to be reviewed. The marketing manager explained the situation in the following manner: "The actual name of our company came from a successful product that was on the market for more than 20 years. Currently, our products are "updated" at least once every five years. Obviously, this reduction =/- 80% in market time has had consequences for internal communications and other processes." Another pressure there was a consensus about among managers is related to achieving "economies of scale." All of them agreed that this pressure has negatively affected the company. Overall, in the production area, it was emphasized that the loss of "economies of scale" goes along with other pressures, namely, "miscellaneous costs" and "customer quality needs". "Miscellaneous costs" are impacted once it is impossible to operate on a production scale that permits decreasing unit costs and/or when total production cost management becomes more difficult to project with high accuracy.

The effects of "customer quality needs" are described with more precision in the words of a production manager: "We know that we will not achieve a gain in scale like the XPTO Company which assembles tractors 2-3km from here. However, for our production line, the big problem is quality control, as all the products are different from one another we have to check each item individually. We don't have lots. This process, in general, takes from three to five working days." The strategy for mitigating this situation is going to be covered in the next section.

The effects of stock level pressure are more latent in the logistics area. A characteristic of this area is that an increase in the product variety offered will impact stock levels in two ways: the first one is strongly related to the number of components comprising the finished product; and the second one to plant location.

Managing the number of components comprising a final product is related to stocking levels in the sense that any increase in the number of components making up a finished vehicle is going to mean a subsequent increase in the number of spare parts which need to be stocked and managed, resulting in a higher total stock level. Plant location is another factor that impacts a stock level, as the company is almost 2.000km distant from some of its most important suppliers. This distance means that stock levels have a tendency to increase. To avoid stock level increases due to distance the company has developed a mitigation strategy which is to be

discussed in the next section.

The pressure of managing the number of components that make up a finished product is not only felt in the logistics area. The environmental area also suffers from the effects of this pressure, which, combined with the necessities of compliance with technical, and legal regulations, and environmental responsibility exerts a great pressure on it. This pressure is made clearer through the words of an environmental manager: “Environmental legislation is becoming more and more restrictive and with this, the environmental area has to adapt to comply with all municipal, state and federal regulations. If we fail in this, the market will stigmatize us as an environmentally unfriendly company which will have direct repercussions on our corporate image in Brazil and the World. Aside from the legal aspects, we have to operate with all the certifications that the market requires and an ever-greater number of components with each new product. When the number of components that make up a micro-bus and/or coach increases, there is a consequent increase in the number of packaging materials and residues that need to be properly remanufactured, recycled or disposed of. Another point that calls our attention is when there is a new technology many times the old technology continues to be utilized and thus there are two types of residues that must be managed. We are living through this now with our highway coaches, for example, with bulbs for interior illumination. The old bulbs were incandescent, while the new ones are LED.”

#### *4.2 Structure and processing*

The company only mentioned supply-chain integration in regard to relationships and participation. To deal with an increase in the variety of components from different suppliers, the body builder looks for integration with its main suppliers by offering share participation to these companies. As the firm operates in a high variety environment, this leads to difficulties in reaching sufficient volume for the suppliers’ minimum lot requirements. Buying a lower number than the required minimum, makes the product (component) too expensive. To avoid this problem, the acquisition of shares in the body builders company by its key suppliers has the objective of guaranteeing the supply of parts and components in whatever quantity is required, now that it is the owner who is ordering them. This adoption of this practice means that the addition of an attribute to the final product does not cause restrictions because of price issues.

A practical example of this was given by a marketing manager: “Last month there was an order from an Argentine client who wanted each seat to be upholstered in a different pattern of fabrics. Do you know what it is to order 46 seats with different fabrics on each one? Well...if we didn’t hold a 40% stake in this supplier, we would have had to pay an absurd amount for each seat or we would have had to wait for months. This strategy differentiates us in the market (differentiation from competitors). Our main competitor has a longer response time than we do to fill this order. This makes a difference in our business. We manage to fill standard orders and even ones like this one, as we say “unexpected,” without great impacts on response time among these products.”

According to the supply-chain integration manager, supply-chain integration is the most important viability-enabling factor in the company’s internationalization strategy. Supply chain integration, in the form that it is carried out by the company, enables the adoption of a follow-sourcing strategy by the firm. In this strategy, a company selects its main suppliers and permits them to have installations for assembly and assistance on the grounds of their overseas plants. In these plants, the suppliers furnish the firm, who benefits through the increase in the reliability of supply. A better relationship with the supplier company, questions related

to quality, delivery times, and not having a need to develop new suppliers are some of the other advantages mentioned for the body builder.

In addition, as the product project is carried out in Brazil, the cost of product variety offered in the overseas markets can be competitive with the competing local companies. This situation is possible, thanks to the elimination of the need for developing new suppliers. Only adaptations for technical and legal regulation compliance in that market are required. In general, a supplier who is selected for follow-sourcing is involved in developing the product in Brazil. This means that the supplier has more intimate knowledge than anyone about the bus that was developed in partnership with the bus builder, as well as all the possible for its components. It means that a lean team of supplier employees, in a specific market, can adapt their component for the final product (buses) in practically any place in the world. Thus, the operation is practically independent of Brazil and can offer the local market essentially the same product variety (bus, microbus or school bus) that is produced in Brazil.

The integration of the bus body manufacturer's employees with those of the supplier outside the country has been pointed out by the logistics manager as being fundamental to the success of a follow-sourcing strategy and for the integration of Brazilian plants. One of the foundations for this employee integration consists of a joint training program, promoted by the body builder itself. These programs have given positive results, which has led the company to amplify and extend the program to Brazil. This amplification has benefited other company areas, especially in regard to production through a business process (material flow management).

The importance of this training program can be verified by the comments of a production manager: "Differently from an automobile, the automation level is low in the assembly of a bus or microbus. In environments that operate with a high product variety such as ours, having adaptable employees is a prerequisite for flexible manufacturing. As a result of this, every year all our employees receive a minimum of 15 days of training. When a new line is launched it may take training of up to three months to accomplish everything. Our employee needs to understand the importance of his job to the whole, understanding the cell before and after him, and all of the production flow. This greatly aids material flow management, as the speed of the line becomes more stable and un-programmed stoppages in the line are minimized. As we have our own employees and those of our outsourcers on the same line it is necessary that everybody speak the same language."

Pressures such as: management of the number of components that comprise a finished product; product lifecycle; technical and legal regulation compliance; and environmental responsibility, when summed up, create huge pressure on business processes, especially returns. On factoring in ever more rigorous environmental regulation and the pressure on the market to incorporate correct environmental practices, the complex situation returns faces in regard to PVM can be observed. Although returns impact the logistics and environmental areas, it is the environmental area which must generate disposal solutions for waste generated. This area must deal with an ever-increasing variety of waste, which is intimately connected to an increase in the variety of product offered. Returns, on their own, cannot deal with all these pressures. It is at this point that returns must be aligned with other business processes, namely product development and commercialization, to be able to jointly resolve these issues.

At first glance, this connection seems a bit out of the ordinary. After all, it would seem to be something quite simple. At the moment the planning stage of a new product is beginning, it is not only the aspects linked to technical issues and the chain of production that must be considered. Aspects related to the disposal and recycling of a product's components at the end of its lifecycle, as well as questions relating to cleaner



production must be taken into consideration when a product is being conceived (DFE). This preoccupation with disposal and recycling of components at the end of the useful life of a product minimizes the reverse-stream flow of materials. Thus, product development and commercialization and returns complement each other in the ways they respond to the pressures created by an increase in product variety, minimizing the amount of waste generated and contributing to a better PVM.

Nevertheless, the bus body manufacturer does not always work with these two business processes interconnected. The importance of this, and the negative consequences of a lack of communication between these two business processes, is brought out in the remarks of an environmental manager. “Until twenty years ago, the development of a product line was carried out uniquely and exclusively by engineering. Marketing helped out with aspects related to the market and competition. Product waste was simply dumped for regular trash collection or at the most went to recycling companies. They came to us (the environmental area) and said: “take this trash from here.” The post-consumption was simply not accounted for. Today the situation is completely different. We are called in to participate and give our opinion at all stages. Logically, the engineering corps has the final word, but they ALWAYS consult us about materials and ecological aspects at all stages of a product’s lifecycle. This new line that was just launched was the project in which we worked together the most. Responding to your question, this allows more items to be customized for our clients, without an uncontrolled increase in the volume of waste and effluents, as we think up and develop internal solutions together with our suppliers to anticipate it. The bus chain must be green!

As the bus body manufacturer’s plant is located around 2,000km distant from some key suppliers, this has an impact on the business plan, particularly procurement. To avoid there being a reduction in variety offered due to the high cost of transportation, the company has adopted a milk-run strategy. Every day, two tractor-trailers leave the plant to collect components from the supplier. With this practice, the company can collect any volume of parts and components, thus avoiding an increase in miscellaneous costs and stock levels. In this way, the distance in relation to suppliers does not act as a restriction on the product variety offered.

In regard to the IT utilized by the body builder, two systems were highlighted: EDI and ERP. These two systems help PVM in two ways. EDI helps in the integration of supply management of materials from the main suppliers of the company. This integration is important for the way it reduces the complexity of supplies, especially in the case of shared components. EDI is utilized for shared components, as it is in this mode that there is a greater demand, orders are more stable, and they are key components for enabling high product variety. ERP contributes to PVM in the way it facilitates and integrates communications between all sectors of the body builder. In this way, all the pressures related to PVM can be accessed online from a common base. As a consequence, the gaps in information related to PVM have been drastically reduced.

In regard to mitigation strategies, it can be noted that they are concentrated in the logistics and production areas. The first and most cited mitigation strategy mentioned was in the process of new-product development, whose consequences impact different mitigation strategies as mentioned in the academic literature through the framework developed in this thesis.

Although academic literature does not think of project development as being a traditional mitigation strategy, all company areas classify it as being an important mitigation strategy whose effects can be felt in many ways.

The first area to point out the effect of this mitigation strategy was production, which can be confirmed in these comments of a production manager: “As we operate on a global scale we need our products to all the regulations. One way we can do this is to adopt the strictest set of regulations as a standard for a determined

region. For example, Brazil has one of the strictest sets of regulations in South America so when we assemble a bus for another South American country we use the Brazilian configuration and only make adjustments for the local regulations. This helps us reducing production time and assembly line complexity. Another advantage for us is that when we develop a new product, even before we fabricate a prototype, engineering already knows the problems we face on that project and thus with this, we have a way of enabling a solution or reducing this time. I am going to give you the example of the double-decker bus. When engineering called us and showed us the project, we said that it would be impossible to do it without us altering our plant layout, as there were some areas of plant that would not accommodate the height of the bus. So, together with engineering we made a new layout to facilitate the production of this new product. In this way, we avoided a problem that would have occurred in prototype production, generating costs and delays in the project.”

The environmental area mentioned that by participating in a project, they could help in the choice of materials, which will reduce waste and effluent production and consequently, environmental costs. This is commented on in more detail by an environmental manager: “When engineering has a new project, and they call us in to collaborate with them on the project with an environmental eye; this brings many benefits for the company. The first one is the application of the DFE (design for environment) concept, or, in other words, thinking of the product as a whole in all phases of its lifecycle. This means that the waste and effluent generated in production will be minimized. We have problems with packaging. As some suppliers also take part in the project, we develop solutions together and in this way avoid costs with disposal for both the suppliers and us. In addition to this, the components that make up the buses are thought out and developed to facilitate the process of recycling and utilization at the termination of the lifecycle of the product. This is particularly interesting as our index of product recyclability increased after this project. To exemplify this to you, when engineering called us in for the first time, the index of recyclability was around 68%, today we have managed to jump to around 82%. The trend is to increase. Furthermore, the volume of packaging disposed of correctly jumped from 89% to 100%, thanks to this interaction between areas.” This contributes to environmental aspects being put in the light of PVM.

Now the financial area points to cost reductions as the principal benefit of joint product development. Although the area had commented that at first there were an increase in costs, the later alignment of the production, logistics, and environmental areas have enabled a reduction in complexity and a greater return on assets. The best allocation of financial resources, starting with joint product development allows maintaining and even increasing product variety offered without having any negative effect on the company’s results.

Yet another mitigation strategy highlighted was the use of common components whose impacts are felt in the production and logistics areas. It was emphasized that the use of common components has a close relationship with the development of products. At the moment in which a new product project is being through, all of its components are developed by the engineering, together with production and logistics, with the goal of verifying the viability of supplies and dealing with restrictions in production, especially the assembly line. Implementing the use of common components thus supports PVM in two places: the supply area and the production process.

In supplies, help comes in the way a smaller number of products flow through inbound logistics. The details and impacts of this help can be perceived in greater detail in these remarks by a logistics manager: “As the supplier participated in the product project, all the components that he supplies are already standardized and with our companies required specifications. With this, problems in not receiving material because of

non-conformity are minimized. To give you a notion, in this class of suppliers the refusal of materials for non-conformity is 92% less than those suppliers who have not participated in a development project for a new bus line.”

In the production area, the effect of the use of common components collaborates with PVM, as this mitigation strategy enables another mitigation strategy, the use of a common process. The effects of this interaction can be felt in the business process of manufacturing flow management. The production line has interchangeable components that help the assembly process now that the average speed increases and the non-programmed stoppages due to problems with materials are reduced. In this way, the production line manages to work in a high variety environment, but with the negative effects on production minimized.

The milk-run strategy is not embraced in academic literature as a mitigation strategy, although it has been cited by the logistics manager as fundamental for mitigating the negative effects of product variety. This consideration of the milk-run as a mitigation strategy could be related to the distance from supply centers. In other words, a company that is close to its supply centers may not use milk-run as a mitigation strategy. To sum up, the logistics manager pointed out that the milk-run is a fundamental strategy for enabling the access to components that it would be difficult for. Considering my specific area the milk-run has a direct impact on final product variety. We are in a city that is very far from the suppliers of ABC Paulista. If we don't send three trailers daily to collect materials and components there or our stock levels will greatly increase, or we will have to reduce the final variety. With the milk-run, we have practically any component in the volume we need, as we are collecting the material at the gate of the supplier. If we hadn't adopted the milk-run, we would have had to reduce our components considerably.”

The employee training program was pointed out by the production and logistics managers as being another important mitigation strategy. For these areas, training workers enables the production line, and its supply, to flow at a more rapid rate with fewer stoppages. When a production line is operating with a high degree of customization, it requires that its workers are able to perform a wide range of activities. Therefore, the yearly training programs set up by the company contribute to PVM in that they mitigate the negative effects of a production environment which must produce a high variety of products in which line speed is high and changing often. The production manager concluded that the training programs' beneficial effects are felt by the company in both its Brazilian plants and the ones overseas

#### *4.3 Output*

Product variety has long been used to increase firm performance (Wagner & Friedl, 2007). Although the measurement of performance is an essential part of the management of product variety it is not verified in the companies researched any measurement of a system product variety and product variety metrics.

Although it is an important factor for PVM neither the assembler, nor the body builder, presented formulas and metrics for evaluating the variety of product offered.

The professionals at the assembly plant were indignant about the lack of ways of evaluating and quantifying product variety and unanimous in affirming that these areas do not possess specific methods for measuring product variety systems or product variety metrics.

The finance manager and the industrial plant director argued that the metrics for evaluating the management of product variety can be obtained by translating them from a company's profits. In this way of thinking, the correct management of product variety is measured by the level of a company's net profits.

However, they emphasized that they do not understand why there is not a way of measuring solely for PVM.

A similar situation was encountered at the body builder, where there are no metrics to evaluate product variety management. The responses of the managers were similar to those of the assembler in which it is considered that the correct PVM is measured by analyzing results of the company as a whole. It was emphasized that as a client can choose and customize an item and generate indicators, there will be low effectiveness as product variety is virtually limitless.

Finally, the outcomes employed by the companies to manage product variety were financial indicators: TIR, liquid profit, and EBTIDA combined with market share.

## 5. Conclusion and future research

This study is the first one to have empirically illustrated product variety management. Our findings show that product variety is an interdisciplinary nature of PVM, as the literature suggests, and its effects can be perceived in all corporate areas in different ways. In this sense, it highlights the importance of holistically analyzing PVM. Additionally, the identification of this range of factors that influence PVM could help practitioners to choose the best methods to manage product variety in their particular environment, specially when operates in emerging market such BRICS. Moreover, it could be useful to mitigate conflicts between different areas. For academics it is important to understand how PVM functions in the business arena.

Regarding the tools used to manage product variety: almost all cited in the academic literature are verified in practice, and some, like milk-run and design for environment, are new findings in the PVM literature.

Although this study is the first step in understanding the PVM phenomena, it refers to a single firm in one industry in one country, so these findings cannot be generalized. In this paper one manufacturing company is researched and the engineering/production area plays an important role in defining the level of product variety offered to the market. Future research should develop comparative studies in different markets and industries to expand our findings and determine which area defines the level of product variety offered to the market.

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